CLAIMS

Sub B1

1. A system comprising a radio-frequency antenna placed in an orbit around the earth, and illuminating means for transmitting and/or receiving likewise orbiting around the earth located on at least a satellite separate from the one bearing the antenna, the antenna being located in the illuminating field of said means, characterized in that the antenna is a transmitting and/or receiving radiofrequency antenna formed of a mesh of tiles, this antenna comprising phase-shifting and/or delaying means connected to these tiles, the signals received by the tiles passing through the phase-shifting and/or delaying means before being retransmitted on said tiles, these phase-shifting and or delaying means being capable of diverting the radio-frequency signals corresponding to one or several channels transmitted by the illuminating means to send them back to the earth along one or several beams and/or of diverting the radio-frequency signals corresponding to one or several beams transmitted from the earth to send them back to the illuminating means along one or several channels.

2. The system according to claim 1, characterized in that the illuminating means are borne by at least one satellite substantially in the same orbit as the one bearing the antenna.

Sub A1

3. The system according to one of claims 1 or 2, characterized in that the radiofrequency antenna is substantially flat, the signals passing from one face to the other of said antenna and for at least one channel and in one path direction, it corresponds, to a direction of illumination along which the illuminating means transmit and/or receive signals to and from the antenna, a cone of "self-compensation" sightings to and from the earth defined by a common incidence on the plane of the antenna, called self-compensation incidence (the incidence of a direction being the angle that this direction makes with the normal to the plane of the antenna), the self-compensation sightings being such that the deformations of the antenna transverse to the general plane of the antenna and the attitude errors of the antenna about any axis contained within said plane are substantially without effect on these same

signals diverted to or from this self-compensation sighting and of small effect in the neighboring sighting directions.

4. The system according to one of the preceding claims, characterized in that each tile includes at least a central portion, unique for a given channel and a path direction, connected by grouping and/or splitting means upstream on the path at at least one signal receiving point and downstream at at least one signal transmitting point and in that means for applying phase-shifting and or delaying between the transmitting and receiving points for ensuring diversion are applied on the central portion with regard to the common delaying and phase-shifting and on the branches with regard to the differential delaying or phase-shifting.

Sub B1

5. The system according to claim 4, characterized in that it includes means enabling the phase-shifting and/or delays applied on the different paths to be varied.

6. The system according to claim 4, characterized in that at least a part of the connecting means between the receiving point or points and the transmission point or points is common to different channels and in that means enabling these different channels to be discriminated are disposed at the level of at least one junction between a portion of common path and portions of specific paths.

Sub A2

7. The system according to one of the preceding claims, characterized in that the antenna includes means for translating the frequency of the signals at the time of their diversion, for at least one channel and one path.

8. The system according to one of the preceding claims, characterized in that for at least one channel and at least one path, the signals use the same frequency before and after the antenna.

9. The system according to claims 3 and 8 taken in combination, characterized in that for an illumination direction of at least one channel along which illuminating means transmit and/or receive signals to and from the antenna and at least one path direction, the self-compensation incidence is equal to the incidence of the illumination direction.

Sub B1

10. The system according to claim 7, characterized in that for at least one channel and at least one path, the signals use a different frequency

before and after the antenna and in that the translation frequency used does not originate from signals received on one of the faces of the tile.

Sub A3

11. The system according to claims 3 and 10 taken in combination, characterized in that for an illumination direction of at least one channel along which illuminating means transmit and/or receive signals to and from the antenna and at least one path direction, the cosine of the self-compensation sighting incidence and the cosine of the illumination direction incidence are substantially in the ratio of the central frequencies of the illumination side and earth side channel.

12. The system according to claim 7, characterized in that along at least one channel and at least one path, the signals use a different frequency before and after the antenna and in that the translation frequency originates from an "external" translation signal received by a tile face.

13. The system according to claim 7, characterized in that along at least one channel and at least one path, the signals use a different frequency before and after the antenna and in that the translation frequency results from or is equivalent to two consecutive translations, one of which is called external and whose translation frequency, termed Fe, originates from an external translation signal received by a tile face and the other of which is called internal and which is of translation frequency Fi, is without reference to a signal received by one or other of the tile faces.

14. The system according to claim 8, characterized in that the illuminating means comprise a plurality of illuminating sub-assemblies and in that different signals from the same channel transmitted to the plurality of illuminating sub-assemblies or originating therefrom are divided between the earth and the antenna along a plurality of transmitting and/or receiving beams whose angular geometry seen from the antenna substantially corresponds to the relative angular geometry along which the different sub-assemblies illuminating this channel are seen from the antenna, this geometry being modified by an anisotropy where necessary.

Sub A4

15. The system according to claim ~~10~~7, characterized in that the illuminating means comprise a plurality of illuminating sub-assemblies and in that, for a given channel for which the antenna implements a translation

frequency, the different signals transmitted to the plurality of illuminating sub-assemblies or originating therefrom are divided along a plurality of transmitting and/or receiving beams toward the earth whose angular geometry seen from the antenna substantially corresponds to the relative angular geometry along which the different sub-assemblies illuminating this channel are seen from the antenna, after multiplication of all the angular differences by the ratio of the central frequencies of the illuminating side and earth side channel, this geometry being modified by an anisotropy where necessary.

16. The system according to claims 12 or 13, possibly taken in combination with claim 15, characterized in that the external translation signal used along at least one channel is transmitted by the illuminating means and received by the antenna face which is on the illumination side, and in that in the case where the illuminating means are split into illuminating sub-assemblies, the external translation signal is transmitted by a sub-assembly called a focus, possibly limited to this function.

17. The system according to claims 3 and 16, characterized in that for an illumination direction of at least one channel, along which illuminating means transmit signals to the antenna while transmitting the external translation signal, the cosine of the self-compensation incidence and the cosine of the illumination direction incidence are substantially in the ratio (f + F - Fe) / f where f is the earth side frequency, Fe is the value of the external translation, and F is the total frequency translation, and in that in the case where the illuminating means are split into sub-assemblies, the difference in incidence between the illumination in question and the focus is substantially reproduced in the difference between the self-compensation incidences corresponding to the illumination and those that would correspond to the focus, using the multiplying terms (f+F/f) and $(\sin(\phi\underline{1}\cancel{2})/\sin(\phi\underline{2}\cancel{1}))$ where $\phi 1$ is the illumination incidence angle of the focus and $\phi 2$ the self-compensation incidence angle that would result if the focus transmitted.

Sub B1

18. The system according to claim 17, characterized in that Fe and F are of the same sign, i.e. relate to changes of frequency in the same direction.

Sub A5

19. The system according to one of claims 12 or 13, ~~characterized in~~ that an external translation signal used along ~~at least~~ one channel in receiving

is received by the tile face along which receiving takes place and is transmitted from a ground point called ground focus.

20. The system according to one of claims 12 or 13, characterized in that an external translation signal used along at least one channel in receiving is received by the tile face along which receiving takes place and is transmitted by at least a satellite substantially in the same orbit as the antenna and the illuminating means, this satellite being arranged in relation to the antenna on the side opposite the illuminating means, the signal transmitting means being called opposite focus.

21. The system according to claim 3 taken in combination with one of claims 19 or 20, characterized in that for an illumination direction of at least one channel, along which illuminating means receive signals, the self-compensation incidence angle is substantially equal to $\phi2 + (\cos(\phi2)\,(f+Fe) - \cos(\phi1)\,(F+f)) / \sin(\phi2)\,f$ where $\phi1$ and $\phi2$ are the angle of incidence of the illumination direction and that of the external translation signal, f the earth side frequency, Fe is the external translation value, and F is the total frequency translation.

5-7 B1

22. The system according to claim 21, characterized in that Fe and F are of the same sign, i.e. relate to changes of frequency in the same direction.

Sub A6

23. The system according to claims 12, 18, 19 and 22 taken in combination, characterized in that for at least one channel used in transmitting and in receiving, the frequency Fe is equal to the frequency F for both paths and at least one ground focus is in the neighborhood of a transmission self-compensation sighting corresponding to these illuminating means.

24. The system according to claims 18 and 22 taken in combination with one of claims 19 or 20, characterized in that for at least one channel used in transmitting and receiving, the attitude of the antenna, as well as the frequencies Fi and Fe both in transmission and reception, are such that the self-compensation sightings are identical on both paths despite the non-alignment of the opposite focus with the illuminating means used in receiving, or in spite of the distance between the ground focus and the center of the zone to be covered.

25. The system according to claims 3 and 16 in combination,

characterized in that for an illumination direction of at least one channel, along which illuminating means receive signals, the translation of frequency Fe is done from the external signal received by the illumination face and the self-compensation incidence is such that cosine (ϕ2)/cosine (ϕ1) = (f +Fe + F)/f where ϕ1 and ϕ2 are the angle of incidence of the illumination direction and the angle of incidence of self-compensation, f being the earth side frequency, Fe the value of the external translation, F the total frequency translation.

Sub B1

26. The system according to claim 25, characterized in that Fe and F are of opposite signs, i.e. the external translation Fe is opposite in direction to the total translation F.

27. The system according to claim 26, characterized in that for at least one channel used in receiving | Fe| =| F | and |Fi=2| F|.

Sub A7

28. The system according to claims 18 and 26 in combination, characterized in that, for at least one channel used in transmitting and receiving, | Fe| =| F| and Fi|=2|F| for receiving and Fe=F for transmitting and in that the self-compensation sightings are substantially the same on both paths.

29. The system according to claims 3 and 16 in combination, characterized in that for an illumination direction of at least one channel, along which illuminating means receive signals, the translation Fe is done from the external signal received by the illumination face and is of the same direction as the total translation F, in that F = Fe and in that the self-compensation incidence is given by ϕ2 - ϕ1 = -2 cot(ϕ1) F/f where ϕ1 and ϕ2 are the angle of incidence of the illumination direction and the angle of incidence of self-compensation, f being the earth side frequency, Fe the value of the translation, F the total frequency translation.

Sub B1

30. The system according to claim 3, characterized in that the attitude of the antenna is such that the angular difference between all the possible sightings and the self-compensation sightings are globally minimized.

Sub A8

31. The system according to claim 3 taken in combination with one of claims 12 or 13, characterized in that the attitude and the translation frequency or frequencies Fe or Fi are such that the angular difference between all the possible sightings and the self-compensation sightings are globally minimized.

32. The system according to claims 3 taken in combination with one of claims 12 or 13, characterized in that the attitude and the translation frequency or frequencies Fe or Fi are such that the self-compensation residues are spread over both paths.

Sub B1

Sub A9

33. The system according to claim 7, characterized in that the antenna includes means for implementing different frequency translations on the radio-frequency signals transmitted or received along separate channels.

34. The system according to claims 1 and 5 taken in combination, characterized in that the phase-shifting and/or delaying means are controlled so as to keep the orientation of a beam corresponding to a channel unchanged in the reference frame associated with the antenna in spite of modifications to the orientation of the illumination direction used by the beam in the reference frame associated with the antenna.

35. The system according to claim 34 taken in combination with one of claims 14 or 15, characterized in that the phase-shifting and/or delaying means are controlled so as to keep the orientation unchanged in the reference frame associated with the antenna, of a possibly virtual beam direction corresponding to a possibly virtual illumination direction referenced with respect to the illumination directions of a channel.

Sub B1

36. The system according to claim 35 taken in combination with claim 4, characterized in that the direction of the possibly virtual beam, on which the compensation bears is chosen so as to minimize the maximum angular difference between this beam and the beam or set of beams of the channel and in that the increment, measured at the wavelength of the central frequency of the earth side channel, between the central points used by the channel is established as a function of this maximum angular difference and the tolerable level of the sub-array lobes accompanying the channel beam or beams.

37. The system according to claim 34, characterized in that it includes means for controlling the phase-shifting and/or delaying means so as to keep the direction of at least one beam of at least one channel unchanged in the earth reference frame in spite of modifications in the attitude of the antenna and modifications that result therefrom concerning the orientation of

illumination directions in the reference frame associated with the antenna.

38. The system according to claim 34, characterized in that the satellite bearing the antenna and at least one satellite bearing the illuminating means include means for determining the orientation of the illumination direction in the reference frame associated with the antenna.

39. The system according to claim 34, characterized in that the satellite bearing the antenna and at least one satellite bearing illuminating means include means for determining the orientation of the axis joining them, in the earth reference frame.

Sub A10

~~40. The system according to claims 38 and 39 taken in combination, characterized in that the orientation of the illumination direction in the reference frame associated with the antenna is determined based on knowing the attitude of the antenna and the orientation of the axis joining them, in the earth reference frame.~~

41. The system according to claim 38, characterized in that the antenna includes means for comparing the phases and/or delays of at least one signal transmitted by the illuminating means and received at different points of the antenna and means for determining according to this comparison the orientation of the direction of arrival of the signal or signals, in the reference frame associated with the antenna.

Sub A11

~~42. The system according to claims 39 and 41 taken in combination, characterized in that the yaw and/or pitch attitude of the antenna is determined based on knowledge of the orientation in the antenna-related reference frame of the direction of arrival of the signal or signals and of the orientation in the earth reference frame of this arrival direction.~~

43. The system according to claim 39, characterized in that a satellite bearing illuminating means includes means for being located or means of receiving radiolocation signals, as well as means for transmitting the location information or the radiolocation signals that it receives to the satellite bearing the antenna, the latter including means for determining primarily according to this information the orientation of the axis joining the two satellites, in the earth reference frame.

Sub A12

44. The system according to claims 35 and 41 taken in combination,

characterized in that the referenced virtual illumination direction is that of an illuminating sub-assembly, which transmits the measurement signal, and in that the measurement immediately gives the information needed for compensation.

Sub B1 45. The system according to claim 15, characterized in that illuminating sub-assemblies are on the same satellite.

Sub A13 46. The system according to claims 14 or 15, characterized in that illuminating sub-assemblies are offset from one another in a common orbit.

47. The system according to one of claims 14 or 15, characterized in that orbits of illuminating sub-assemblies have differences in ellipticity and/or orbital plane.

Sub B1 48. The system according to claim 7, characterized in that on a central portion delay, everything is routed to at least one channel and the translation line, or a reference enabling it to be created, used for reducing the frequency of the channel or channels downstream of the delay, so as to limit the impact of delay imperfections on the phase of the diverted signal.

49. The system according to claim 7, characterized in that a downlink translation is implemented on one channel or several channels upstream of the central portion delay.

50. The system according to claim 49, characterized in that such a downlink translation is followed by an uplink translation after the delay using a reference not having suffered this delay, so as to limit the impact of delay imperfections on the phase of the diverted signal.

51. The system according to claim 6, characterized in that the delay on the central portion is common to at least two channels on at least one path direction.

Sub A14 52. The system according to claims 6 and 7, characterized in that the frequency translation is implemented, on at least one channel and one path, in the central portion.

53. The system according to one of claims 14 or 15, characterized in that, in one telecommunications transmission application, it comprises a plurality of channels, together with a plurality of illuminating sub-assemblies, the beam mosaic on the ground consisting of the fine pattern generated by

the antenna due to the angular geometry along which the illuminating sub-assemblies are seen by it, repeated along a wide pattern that is generated by the antenna due to the different channels.

54. The system according to claims 53 and 47, characterized in that the illuminating sub-assemblies illuminating the same channel are seen from the antenna according to a relatively stable angular geometry except for a rotation about itself at the orbital period and in that the plurality of directions ensured by the wide pattern of the channel precesses thanks to the phase-shifting and/or delaying means around a central direction and this in phase with the rotation of the fine pattern so that the mosaic of all the beams keeps a stable structure, apart from a rotation about itself on the orbital scale.

Sub B1

55. The system according to claim 2, characterized in that the orbit of the satellites is a low orbit and in that the antenna extends substantially in a plane that passes through the center of the earth, in that an offset of the plane in relation to the orbital plane enables illumination on one face, in that on the other face at least one of the beams is realigned to see the earth.

SubA15

56. The system according to claims 55 taken in combination with ~~claim~~ 46, characterized in that the phase shifts and delays ~~are such~~ that the offset of the illuminating sub-assemblies ~~is~~ expressed by beams with ground footprints ~~offset~~ transversely with respect to the track.

Sub B1

57. The system according to claim 2, characterized in that at least two antenna satellites use common illuminating means.

58. The system according to claim 57, characterized in that at least two antenna satellites are located on the same side, along the orbit, of the illuminating means, and in that they are offset on the same orbit or are offset in ellipticity and/or orbital plane.

59. The system according to claim 57, characterized in that at least two antenna satellites are on each side of the illuminating means.

SubA16

60. The system according to one of claims 57 to ~~59, characterized~~ in that one antenna ~~satellite bears~~ illuminating means for another antenna ~~satellite~~.

Sub B1

61. The system according to claim 60, characterized in that one prism satellite bears illuminating means for another prism satellite and is illuminated

by illuminating means borne by a prism satellite.

62. The system according to claims 2 and 3, characterized in that the axis normal to the antenna is substantially in the orbital plane, the pitch being such that the self-compensation sighting cone meets the earth along a self-compensation line globally stretching transversely to the orbit and in that the ground displacement, substantially along the projection of the orbit, of the line of self-compensation is created by the displacement of the satellite and/or by the change in pitch of the antenna axis and/or the change in translation frequency in the case where this is ensured at least by an internal signal, these three means being able to be used separately or in combination.

63. The system according to claim 62, characterized in that the the ground sightings are spread in a swath along the line of self-compensation in such a way that the antenna's deformation constraints are very relaxed.

64. The system according to claim 2, characterized in that illuminating means receive signals directly from the earth also received via the antenna and in that a correlation between the two incoming signal paths makes a sighting discrimination of the source of these signals as a function of the angle that the direction of arrival of the signals makes with the antenna/illuminating means axis.

65. The system according to claim 64, characterized in that the displacement on the ground, substantially along the orbit's projection, of the sighting zone discriminated by correlation is achieved by the displacement of the satellite and/or by changing the angle of discrimination.

66. The system according to claim 65, characterized in that the antenna presents a larger dimension in one direction than in the other directions, which for at least one beam ensures the narrowness of the footprint on the ground in a direction transverse to the orbit.

67. The system according to claims 65 and 66 taken in combination, characterized in that ground imaging along two cross components is obtained by combining the correlation and a beam scan.

68. The system according to claims 63 and 67 taken in combination, characterized in that it includes means for performing ground sightings based on an electronic scan of a beam according to a monodimensional control and

in that the large dimension of the beam footprint, which results from the small dimension of the antenna, is along the orbit and enables the coverage of the self-compensation line for all positions of the beam, in spite of the curvature of this line and the mono-dimensional nature of the scanning control.

69. The system according to claim 68, characterized in that the antenna is extended along the pitch axis.

Sub A17

70. The system according to claims 67 and 55 taken in combination, characterized in that the antenna is extended along the yaw axis.

71. The system according to one of the preceding claims characterized in that the antenna has means for measuring or reconstructing the deformation (ΔP) transverse to the plane of the antenna.

72. The system according to claim 71, characterized in that the antenna includes means for comparing the phases and/or delays of at least one signal transmitted by the illuminating means and received at different points of the antenna and means for determining according to this comparison the deformation (ΔP) transverse to the plane of the antenna.

Sub A18

73. The system according to claims 3, 5, 8 and 71, characterized in that for an illumination direction of at least one channel along which illuminating means transmit and/or receive signals to and from the antenna and at least one path direction, a deformation correction is made by variation of the phase-shift value ΔP (2Π f/C) (cos(ϕ2)- cos(ϕ1)) in at least one of the central portions, where ϕ1 is the angle of incidence of illumination, ϕ2 is that of the sighting direction, f is the earth side and illumination side frequency, and ΔP is the transverse deformation value at each of the central portions.

74. The system according to claims 3, 5, 10 and 71, characterized in that for an illumination direction of at least one channel along which illuminating means transmit and/or receive signals to and from the antenna and at least one path direction, a deformation correction is made by variation of the phase-shift of value ΔP (2Π f/C)- f1 (cos(ϕ2)- cos(ϕ1)) in at least one of the central portions, where ϕ1 is the angle of incidence of illumination, ϕ2 is that of the sighting direction, f2 and f1 are the earth side and illumination side frequencies, and ΔP is the transverse deformation value at each of the central

portions.

75. The system according to claims 3, 5, 16 and 71, characterized in that for an illumination direction of at least one channel, along which illuminating means transmit signals to the antenna, a deformation correction is made by variation of the phase-shift of ΔP (2Π/C) (f cos(ϕ2)- (f+ F) cos(ϕ1) + Fe cos(ϕ'1)) in at least one of the central portions, where f is the earth side frequency, Fe is the measured external translation value of the same sign as F if the frequency changes are in the same direction, F is the total frequency translation, ϕ1 is the angle of incidence of illumination, ϕ2 is that of the sighting direction, ϕ'1 is that of the focus direction, ΔP is the transverse deformation value at each of the central portions.

76. The system according to claims 3, 5, 16 and 71, characterized in that for an illumination direction of at least one channel, along which illuminating means receive signals, a deformation correction is made in at least one of the central portions by variation of the phase-shift of ΔP (2Π/C) (f cos(ϕ2)- (f+ F) cos(ϕ1) - Fe cos(ϕ'1)) where f is the earth side frequency, Fe is the measured external translation value of the same sign as F if the frequency changes are in the same direction, F is the total frequency translation, ϕ1 is the angle of incidence of illumination, ϕ2 is that of the sighting direction, ϕ'1 is that of the focus direction and ΔP is the transverse deformation value at each of the central portions.

77. The system according to claims 3, 5 and 71, taken in combination with one of claims 19 or 20, characterized in that for an illumination direction of at least one channel, along which illuminating means receive signals, a deformation correction is made in at least one of the central portions by variation of the phase-shift of ΔP (2Π/C) (f cos(ϕ2) + Fe cos(ϕ'2) - (f+ F) cos(ϕ1)) where f is the earth side frequency, Fe is the measured external translation value of the same sign as F if the frequency changes are in the same direction, F is the total frequency translation, ϕ1 is the angle of incidence of illumination, ϕ2 is that of the sighting direction, ϕ'2 is that of the ground focus or opposite focus direction and ΔP is the transverse deformation value at each of the central portions.